Dry Sliding Wear and Mechanical Characterization of Marble Dust and Egg Shell Filled Al6061 Metal Matrix Composites for Tribological Applications

SYNOPSIS OF THE THESIS

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DECLARATION

I hereby declare that the dissertation synopsis entitled **"Dry sliding wear and mechanical characterization of marble dust and egg shell filled Al6061 metal matrix composites for tribological applications"** to be submitted for the partial fulfilment of the Degree of Doctor of Philosophy is my original work and the dissertation has not formed the basis for the award of any degree, diploma, associateship or fellowship of similar other titles. It has not been submitted to any other University or Institution for the award of any degree or diploma.

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Introduction:

A progressive loss of material from the surface of any component is called wear. It is a material response to the external stimulus and can be mechanical or chemical in nature. Wear is unwanted and the effect of wear on the reliability of industrial components is recognized widely; also, the cost of wear has also been recognized to be high. Systematic efforts in wear research were started in the 1960's in industrial countries [1]. The direct costs of wear failures, i.e., wear part replacements, increased work and time, loss of productivity, as well as indirect losses of energy and the increased environmental burden, are real problems in everyday work and business. In catastrophic failures, there is also the possibility of human losses. Although wear has been extensively studied scientifically, in the twenty-first century there are still wear problems present in industrial applications. This actually reveals the complexity of the wear phenomenon [2,3].

Sliding wear is a typical wear mode, is the loss of material that results from rubbing of hard surface on the smooth surface. In some cases, sliding wear is a useful phenomenon, but it is a serious problem in many engineering systems, including turbines, moving parts in automobiles, spacecrafts, and many industrial systems [4]. Differences in the sliding wear behaviour of various types of composite materials are caused by the amount, type, orientation, and properties of the reinforcement on the one hand and by the type and properties of the matrix and its adhesion to the fibers/fillers on the other [5]. A full understanding of the effects of all system variables on the wear rate is necessary in order to undertake appropriate steps in the design of machine or structural component and in the choice of materials to control wear [6]. Sliding wear, as already mentioned, is a dynamic process that occurs in different machine parts due to the loss of material from soft surface by the action of hard surface. The exposed components undergo material removal and surface degradation. Similar to other tribological processes, sliding wear is also a combined process: the mechanical load may be associated with secondary thermal, chemical, and physical reactions between the counterparts involved in the tribological system [7]. Attempts to understand the basic mechanisms of the sliding wear started in the last half of the twentieth century and have been continued to the present. All these years the interest of the scientists was concentrated on conventional materials and especially metals. A comprehensive and systematic investigation of sliding wear in metal matrix composites reinforced with natural or industrial wastes has not yet been performed. Extensive research is therefore needed to

develop various methods and theoretical models for predicting sliding wear behaviour and its dependence on the proportion of the components and the composite-micro-structure.

Review of literature:

S. B. Hassan et.al [8] studied the effects of carbonized and uncarbonized eggshell particles (ES) on the microstructures and mechanical properties of Al–Cu–Mg/ES particulate composites. The results revealed that the tensile strength and hardness are increased for carbonized and uncarbonized eggshell reinforced composites. Whereas the density and impact strengths are decreasing for both carbonized and uncarbonized eggshell reinforced composites. S. P. Dwivedi et.al [9] and studied the effect of eggshell particle reinforcement in AA2014 aluminium alloy, and found that tensile strength and the fatigue strength for the composites containing 2.5wt.% SiC up to 7.5wt.% carbonized eggshell were observed to be higher than that of the other selected composites. The results also show that toughness decreases with the increase in the weight ratio of Si and carbonized eggshell in the composites. M. T. Hayajneh et.al [10] produced Al alloy metal matrix composites by powder metallurgy technique reinforcing eggshell particles. The results showed that the addition of 3 wt.% of eggshell improved wear resistance (65%), compressive strength (40%) and hardness (15%). N. H.Ononiwu et.al [11] studied the effect of the carbonization temperature on the mechanical properties, density, wear and corrosion resistance of AA 6063 reinforced with eggshells. The selected fabrication route for this investigation was stir casting while the weight fraction of the eggshells was kept constant at 5 wt.%. The carbonization temperature was varied at 900, 1000, 1100, and 1200°C. The microstructure revealed that the eggshells were fairly uniformly dispersed on the individual grains and along the grain boundaries of the base metal. The analysis of the micro-hardness showed an improvement of 40.79, 22.93, 25.70, and 29.43% for the 900, 1000, 1100, and 1200°C carbonized eggshell samples, respectively. The compressive strength studies showed that the addition of carbonized eggshells improved the compressive strength of the composites compared to the base metal. The tribology studies showed that the wear resistance improved for the 900 and 1200°C samples, while the electrochemical studies revealed that the corrosion resistance improved for the 900 and 1000°C samples only.

Many researchers have also studied the effect of industrial waste marble dust reinforcement on aluminium alloy metal matrix composites. Swati et al. [12], reinforced marble dust in Silicon-Bronze alloy, proportions of marble dust were varied from 0 wt. % to 10 wt. % with a gap of 2.5 wt. %. Silicon-Bronze alloy used for bearing application, reinforcement done with the help of stir casting technique. The tribological properties friction and wear determined by pin on disc tribometer under different environment condition for fuzzy VIKOR methodology, to get optimal composite among available alternatives. s, it was found that silicon-bronze-3 marble dust bearing material containing 7.5 wt. % marble dust achieved the best possible set of the properties for wear resistant applications.Vimal et al.[13], reinforced marble dust in ZA-27 alloy, with varying wt.% of marble dust from 0 to 10% with a gap of 2.5 wt.%. t, this paper presents a novel hybridization of an improved bat algorithm (IBA) trained artificial neural network for predicting wear properties of marble dust reinforced ZA-27 alloy composites.Marble dust- reinforced C93200 by Santosh et al.[14], composites made with marble dust reinforcement (1.5 to 6.0 wt.%) were manufactured using the liquid metal stir casting technique. Where the maximum hardness and maximum tensile strength is found in 4.5 wt.% composite. Wear micrographs of 4.5 wt.% marble dust reinforced composite exhibit superior wear performance in respect to other combination analysed which make it preferable for bearing applications.Copper-Based Alloy (C93200) composites reinforced with marble dust Developed by Santosh et al.[15], with a different weight percentage of marble dust particles (1.5, 3, 4.5, and 6 wt.%) were developed by stir casting method under vacuum environment. the preference selection index (PSI) technique used for best composite selection. PSI method proposed permitted us to well define the final ranking for the material developed which is categorized as 4.5>3>6>1.5>0 wt.% marble dust reinforced composite in all mechanical and tribological properties for bearing applications.Reusing marble dust as reinforcement material for better mechanical performance has been studied by Vipin et al.[16], Waste marble dust particles were used as reinforcements in the Al 6063 aluminium matrix. Composite were fabricated by stir casting technique, by preheating marble dust 200^0c,100^0c and room temperature. Composite processed with 200^0c preheated marble dust shows maximum tensile, maximum hardness and minimum wear rate.Tribological and Microstructure Examination of Environmental Waste (Marble Dust) Filled Silicon Bronze Alloy for Wear Resistant Applications studied by Swati et al.[17], composite was fabricated in five different wt.% of marble dust. Where Taguchi (L_{25} orthogonal array) technique used for wear calculation. In overall 75 wt.% marble dust composite shows batter mechanical properties and wear resistance.Ashwani et al.[18], studied

mechanical and tribological performance of marble dust 7075 aluminium alloy composites, composite were fabricated with 0 to 6 wt.% of marble dust. Composite of 6% marble dust shows maximum wear resistance because it has maximum hardness.

Aim and Objective:

After the extensive literature study on the eggshell and marble dust reinforced metal matrix composites, there is no study found on the sliding wear and mechanical behaviour of eggshell and marble dust reinforced Al6061 metal matrix composites. Based on the research gap following objectives have been decided for this work.

1. To fabricate the eggshell and marble dust particles reinforced Al6061 metal matrix composites by stir casting technique.
2. To study the physical and mechanical characterization of eggshell and marble particles reinforced Al6061 metal matrix composites.
3. To study the sliding wear behaviour of eggshell and marble particles reinforced Al6061 metal matrix composites.
4. To study the effect of control factors on sliding wear behaviour of eggshell and marble particles reinforced Al6061 metal matrix composites using Taguchi technique.
5. To study the microstructures of the wear surfaces of eggshell and marble particles reinforced Al6061 metal matrix composites.

Methodology:

In the proposed research, Al6061-based composite reinforced with Eggshell and Marble Dust will be developed for enhanced wear resistance. The methodology of the research will involve the preparation of samples for sliding wear and mechanical characterization as per ASTM standards. The experiments will be carried out to determine the density, hardness, impact strength, tensile strength, micro hardness, and sliding wear resistance of the composite material.

Taguchi method will be applied for process optimization to enhance the properties of the composite material. ANOVA analysis will be performed to determine the significant

factors affecting the properties of the composite material. Micrograph study through SEM will also be carried out to investigate the microstructure of the composite material.

The mechanical characterization and sliding wear test results will be analysed, and the factors affecting the properties of the composite material will be discussed. The research will conclude with a summary of the research findings, conclusions, and future directions for research in the field of Al6061-based composites reinforced with Eggshell and Marble Dust for enhanced wear resistance.

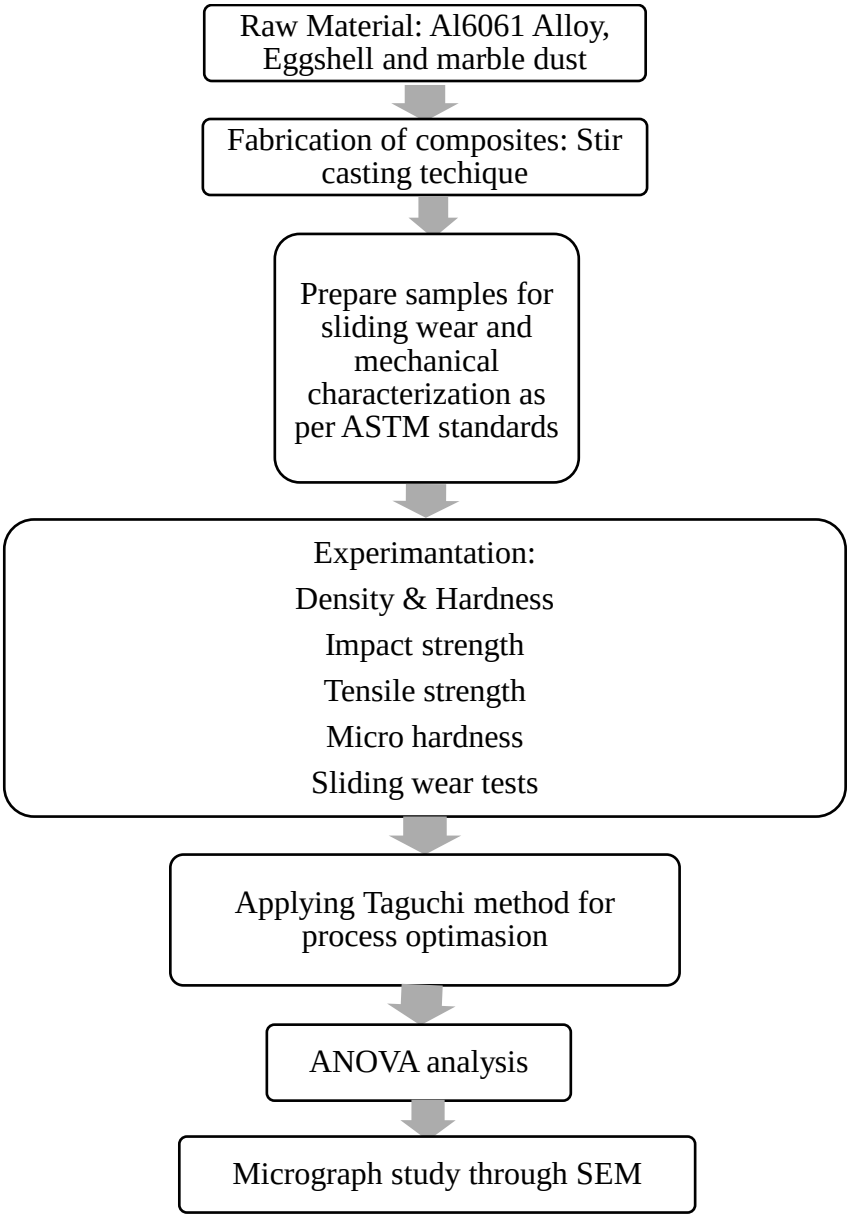
Raw Material: Al6061 Alloy, Eggshell and marble dust
Fabrication of composites: Stir casting techique
Prepare samples for sliding wear and mechanical characterization as per ASTM standards
Experimantation:
Density & Hardness
Impact strength
Tensile strength
Micro hardness
Sliding wear tests
Applying Taguchi method for process optimasion
ANOVA analysis
Micrograph study through SEM

Fig.1.Methodology

Expected Outcomes:

The study is expected to provide a better understanding of the effect of marble dust and eggshell fillers on the dry sliding wear behaviour and mechanical properties of Al6061 MMCs. The research will contribute to the development of new MMCs with improved tribological properties, which could be used in various industrial applications. The study will also provide insights into the microstructural characteristics that influence the tribological properties of MMCs. The results of the study could help in the selection of suitable filler materials and weight percentages for the development of MMCs with specific tribological requirements.

Conclusion:

The proposed research aims to investigate the dry sliding wear behaviour and mechanical properties of Al6061 MMCs reinforced with marble dust and eggshell fillers. The study is expected to provide a better understanding of the effect of fillers on the tribological properties of MMCs and contribute to the development of new MMCs with improved wear resistance. The results of the study could have practical implications in the selection of suitable MMCs for various industrial applications.

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